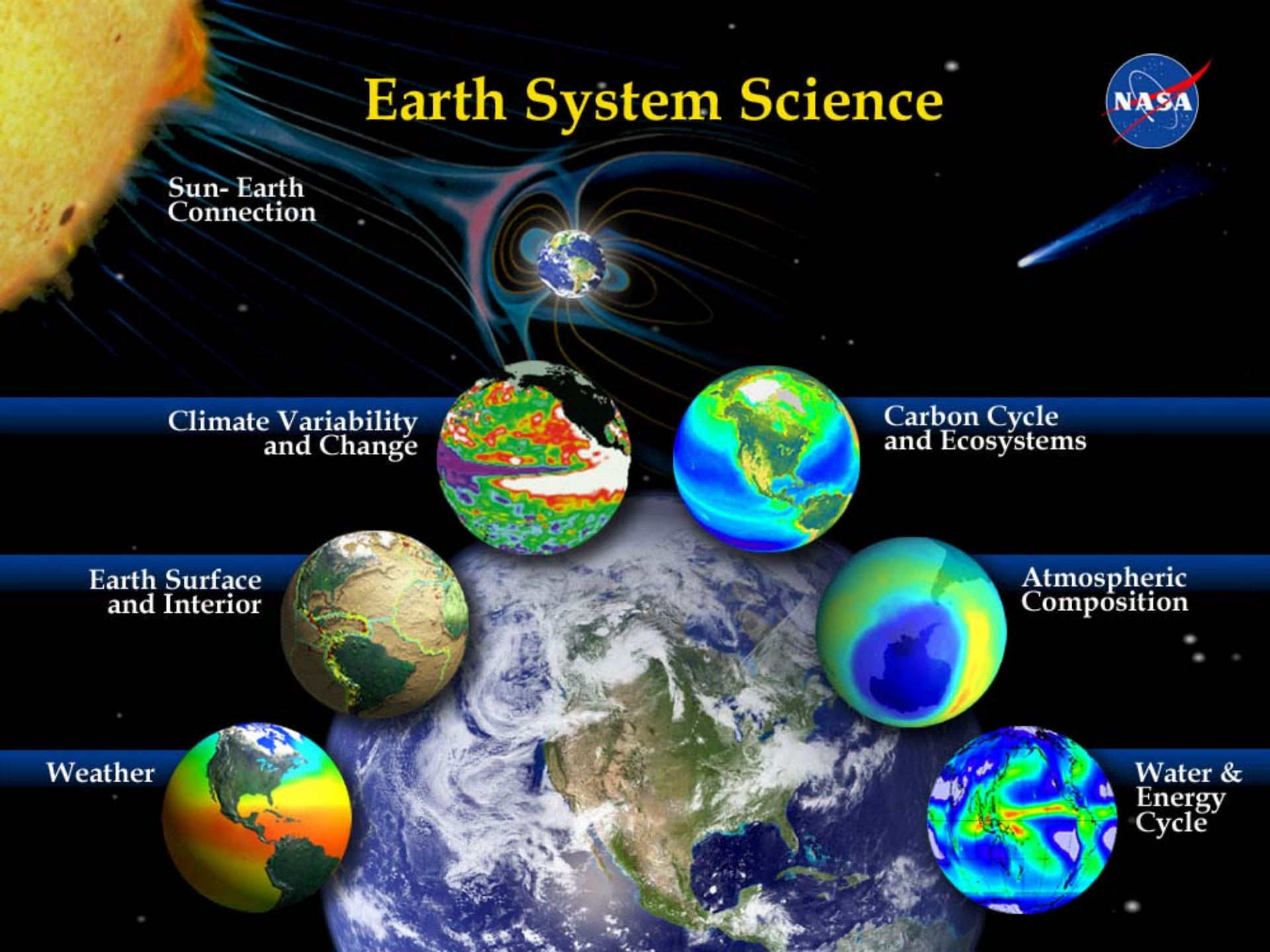
Solar Occultation Satellite Science Team

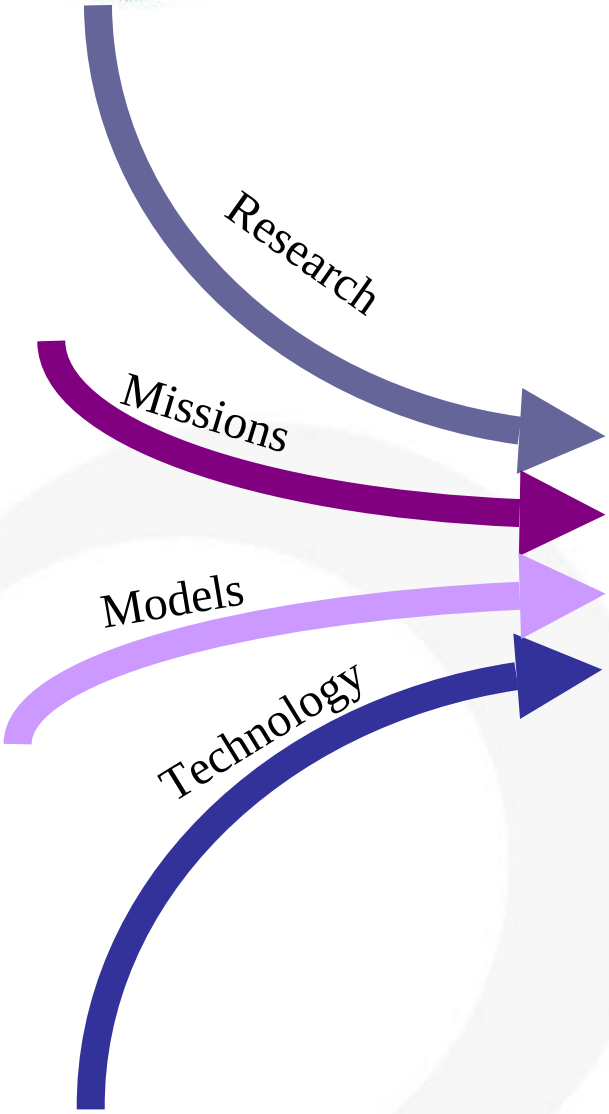
HQ Context

Phil DeCola

Earth System Science

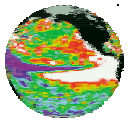


Focusing ESE Assets on Answering Specific Questions

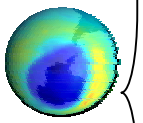


Carbon Cycle & Ecosystems (CO_2, CH_4)

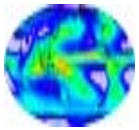
Climate Variability & Change (atmospheric constituent effects on climate)



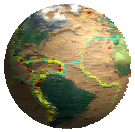
Atmospheric Composition



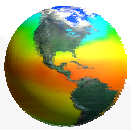
Water &Energy Cycle (atmospheric water vapor)



Earth Surface & Interior (volcanic effects on atmosphere)



Weather (effects on air quality)



How is atmospheric composition changing?

What trends in atmospheric constituents and solar radiation are driving global climate?

How do atmospheric trace constituents respond to and affect global environmental change?

What are the effects of global atmospheric chemical and climate changes on regional air quality?

How will future changes in atmospheric composition affect ozone and climate?

Focus Areas Interact

Important Inputs and Outputs

Vegetation Dynamics - Emissions
Chemical Deposition - Vegetation

Temp Affects Chemistry/Dynamics
Constituent Affects Climate

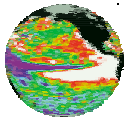
Water Vapor - Oxidation Capacity
Aerosols - Clouds and Precipitation

Volcanic Emissions

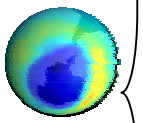
Lightning NO_X, Wet Deposition
Improved Weather Prediction

Carbon Cycle & Ecosystems
(CO_2, CH_4)

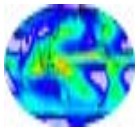
Climate Variability & Change
(Chemistry-Climate Couplings)



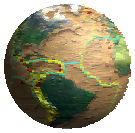
Atmospheric Composition



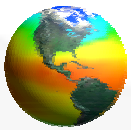
Water &Energy Cycle
(atmospheric water vapor)



Earth Surface & Interior
(volcanic effects on atmosphere)



Weather
(effects on air quality)



How is atmospheric composition changing?

What trends in atmospheric constituents and solar radiation are driving global climate?

How do atmospheric trace constituents respond to and affect global environmental change?

What are the effects of global atmospheric chemical and climate changes on regional air quality?

How will future changes in atmospheric composition affect ozone and climate?


The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

Focus Area Drivers: National Priorities

- The Earth's Ozone Shield is fundamental to protecting all life.
- The Earth's Air Quality is fundamental to public health.
- The Earth's Climate is affected by changes in greenhouse gases and aerosols.

"America and the world share this common goal: we must foster economic growth in ways that protect our environment. We must encourage growth that will provide a better life for citizens, while protecting the land, the water, and the air that sustain life. In pursuit of this goal, my government has set two priorities: we must clean our air, and we must address the issue of global climate change."

President George W. Bush, February 14, 2002

Focus Area Drivers: National Priorities
Climate Change Research & Technology

Climate Science and Technology Management Structure

Office of the President
Climate Change Policy and
Program Review by NSC, DPC, NEC

Committee on Climate Change Science and Technology Integration
Chair: Secretary of Commerce* Vice Chair: Secretary of Energy*
Executive Director: OSTP Director

Secretary of State	NEC Director	Secretary of Transportation
Secretary of Agriculture	NASA Administrator	Secretary of Defense
EPA Administrator	Secretary of the Interior	CEQ Chairman
OMB Director	Secretary of HHS	NSF Director

International Activities
(Including Task Force on International Energy Cooperation)

DOS, DOE, USAID and Other Agencies

Interagency Working Group on Climate Change Science and Technology
Chair: Deputy/Under Secretary of Energy*
Vice Chair: Deputy/Under Secretary of Commerce*
Secretary: OSTP Associate Director for Science
Members DS/US Level:
CEQ, DOD, DOI, DOS, DOT, EPA,
HHS, NASA, NEC, NSF, OMB, USDA

Climate Change Science Program
Director: Assistant Secretary of Commerce for Oceans and Atmosphere
Members: DOC, DOD, DOE, DOI, DOS, DOT, EPA, HHS, NASA, NSF, OMB, OSTP, Smithsonian, USAID, USDA

Climate Change Technology Program
Director: Assistant Secretary of Energy for Energy Efficiency and Renewable Energy
Members: DOC, DOD, DOE, DOI, DOS, DOT, EPA, HHS, NASA, NSF, OMB, OSTP, USAID, USDA

*Chair and Vice Chair of Committee and Working Group rotate annually

CCSP Deliverables

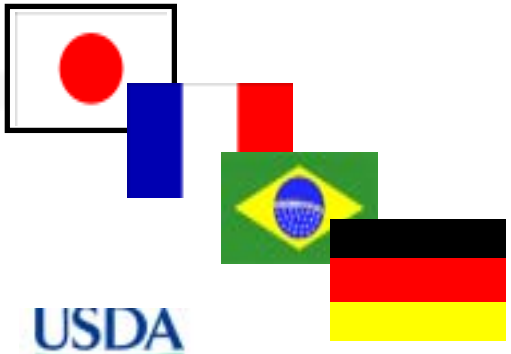
CCSP Goal 1 ***Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and change***
CCSP Goal 2 ***Improve quantification of the forces bringing about changes in the Earth's climate and related systems***
CCSP Goal 3 ***Reduce uncertainty in projections of how the Earth's climate and environmental systems may change in the future***
CCSP Goal 4 ***Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes***
CCSP Goal 5 ***Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change***

CCTP Deliverables

"Accurate measurements underlie many climate related actions and strategies for reducing GHG (greenhouse gas) *emissions. Improving the ability to measure and monitor GHG emissions, inventories, and fluxes is a top priority. Advances in the science of remote sensing from high altitudes and space, coupled with land-based measurements, create new opportunities to better measure and monitor GHG emissions and concentrations. In order to meet basic measurement needs in this area, future R&D will be needed to develop a comprehensive and integrated array of GHG sensors, measurement platforms, monitoring systems, inventorying systems, and related mathematical and statistical inference methods."*

Partnerships Are Essential

- International
  - Over 290 agreements with approximately 60 different countries
  - International research programs with multilateral organizations such as FAO, UNEP, WMO, WHO and CCAD
- Interagency
  - Joint weather satellite programs with NOAA & DoD
  - Landsat with DOI/USGS
  - Research and applications with USDA, DOT, NSF, FEMA, USFS
  - US Climate Change Science Program
- Regional, State & Local
  - Associations of states, counties and cities
  - Consortia of local governments and universities
- Commercial
  - Traditional industrial partnerships
  - Purchases of commercial data
  - Targeted advanced technology collaborations



International Assessments

- WMO/UNEP Ozone Assessment
- Intergovernmental Panel on Climate Change (IPCC)
- IPCC Special Report on Aviation
- WCRP/SPARC Assessments

Purpose of the Focus Area Reviews

- Review Plans and Progress For Accomplishing ESE Goals
  - Short-term
  - Long-term
- Demonstrate for Our ESE Leadership/Management That We Have Our Act Together in Focus Area
- Communicate Top Level Issues and Messages to ESE Leadership/Management and Entire Enterprise
- Preparation Process Invaluable for Focus Area Team
  - Taking Stock of Top Level Issues
  - Enhancing Connections Within Our Focus Area Team
- Working Meeting for the Entire Enterprise to Discuss Issues and Formulate Action Plan for Meeting Challenges and Implementing Strategy

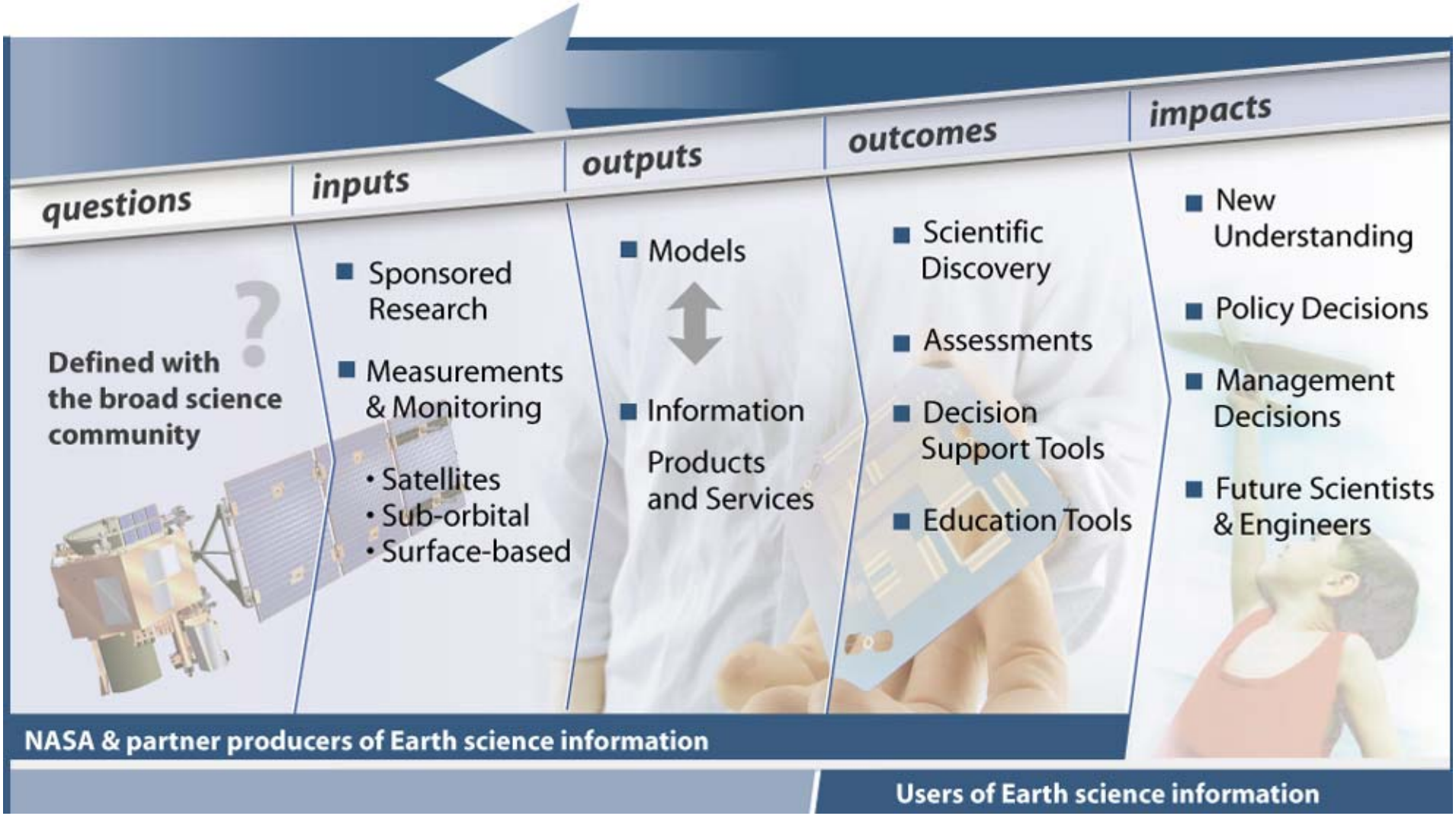
Top Issues for Last ACFA Review

- Interpreting “As Only NASA Can” and the Importance of the “End to End” Approach
- Suborbital Capabilities: We Want To Be Part of the Solution
  - Near-term Transition
  - Future Directions
- Climate Data Records
  - Maintaining Those Already Established
  - Identifying Those Emerging
- Defining NASA Niche in National Air Quality Deliverables
- Identifying NASA Contributions To CCSP and CCTP Deliverables
- Quantifying Future Computational Needs for Atmospheric Composition

Why NASA?

- Global scale changes require a global perspective, and local and regional changes can only be fully understood in their global context. NASA brings the ability to study the Earth as a planet
- NASA has the capability to address research problems with an “end-to-end” approach, and the program management expertise to help lead complex, multi-partner research endeavors
- NASA has specific expertise in Earth observation, interdisciplinary research and Earth system modeling
- NASA has connections to agencies with operational missions to facilitate the incorporation of new knowledge and tools into the services these agencies provide to the nation

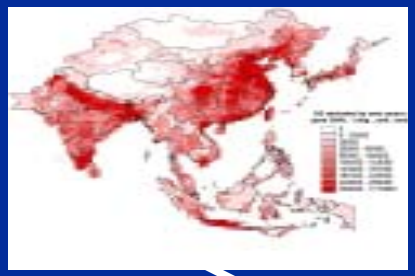
Organizing Principle for ACFA
From Science to Society
(and Back Again)



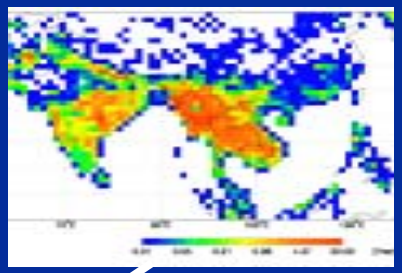
INTEGRATION OF TRACE-P, MOPITT, AND GEOS-CHEM TO QUANTIFY CARBON MONOXIDE SOURCES FROM ASIA

A PRIORI EMISSIONS (customized for TRACE-P)

Fossil and biofuel (bottom-up stats)



Daily biomass burning (satellite fire counts)



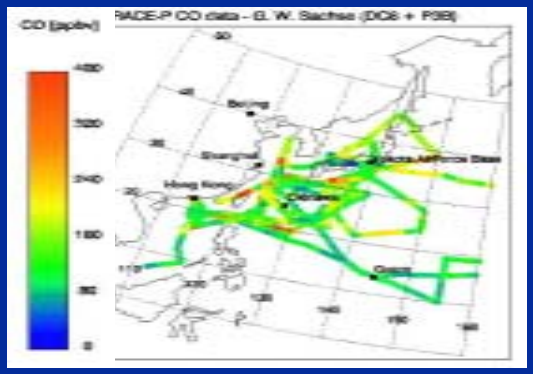
GEOS-CHEM CTM

chemical forecasts

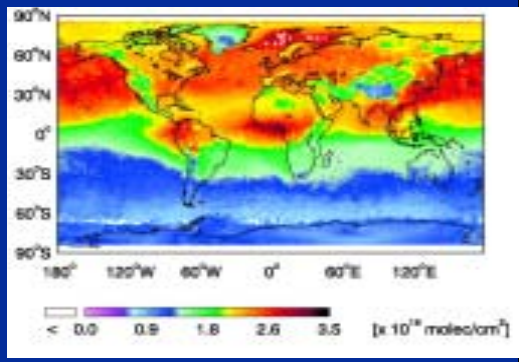
top-down constraints

INVERSE ANALYSIS

TRACE-P CO DATA



validation

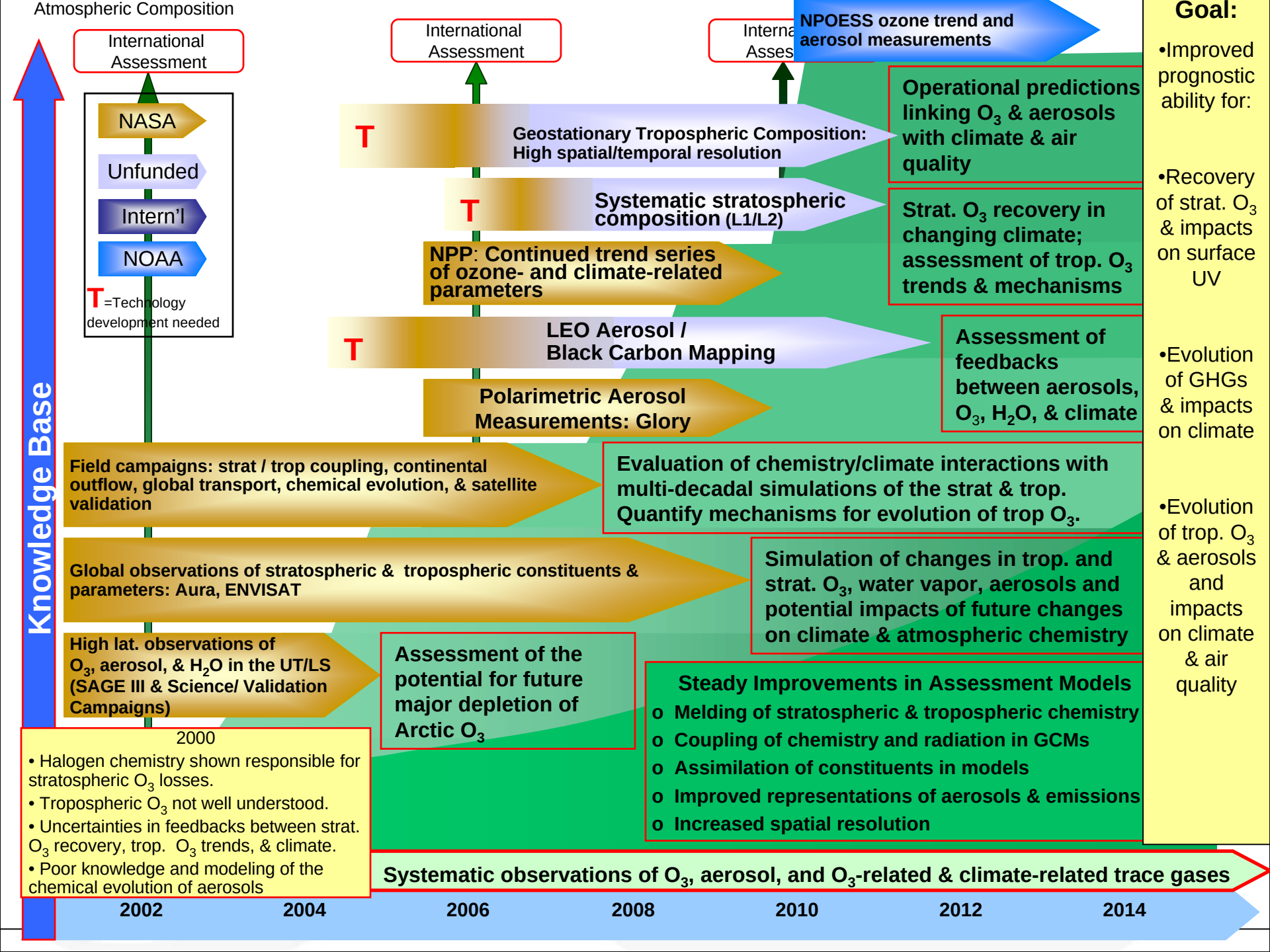


MOPITT CO March-April 2001

- A priori Chinese emissions too low by 50% (domestic fuel)
- A priori SE Asian biomass burning emissions too high by 60%
- Japan, Korean emissions correct within 20%

DECISION SUPPORT: improved estimates of

- domestic fuel emissions (air pollution control policy)
- Asian carbon outflow (climate policy)


Atmospheric Composition
International Assessment
NASA
Unfunded
Intern'l
NOAA
T=Technology development needed
International Assessment
Interna
Asses
NPOESS ozone trend and aerosol measurements
T
Geostationary Tropospheric Composition: High spatial/temporal resolution
Operational predictions linking O_3 & aerosols with climate & air quality
T
Systematic stratospheric composition (L1/L2)
Strat. O_3 recovery in changing climate; assessment of trop. O_3 trends & mechanisms
NPP: Continued trend series of ozone- and climate-related parameters
T
LEO Aerosol / Black Carbon Mapping
Assessment of feedbacks between aerosols, O_3, H_2O, & climate
Polarimetric Aerosol Measurements: Glory
Field campaigns: strat / trop coupling, continental outflow, global transport, chemical evolution, & satellite validation
Evaluation of chemistry/climate interactions with multi-decadal simulations of the strat & trop. Quantify mechanisms for evolution of trop O_3.
Global observations of stratospheric & tropospheric constituents & parameters: Aura, ENVISAT
Simulation of changes in trop. and strat. O_3, water vapor, aerosols and potential impacts of future changes on climate & atmospheric chemistry
High lat. observations of O_3, aerosol, & H_2O in the UT/LS (SAGE III & Science/ Validation Campaigns)
Assessment of the potential for future major depletion of Arctic O_3
Steady Improvements in Assessment Models
o Melding of stratospheric & tropospheric chemistry
o Coupling of chemistry and radiation in GCMs
o Assimilation of constituents in models
o Improved representations of aerosols & emissions
o Increased spatial resolution
Knowledge Base
2000
• Halogen chemistry shown responsible for stratospheric O_3 losses.
• Tropospheric O_3 not well understood.
• Uncertainties in feedbacks between strat. O_3 recovery, trop. O_3 trends, & climate.
• Poor knowledge and modeling of the chemical evolution of aerosols
Systematic observations of O_3, aerosol, and O_3-related & climate-related trace gases
2002
2004
2006
2008
2010
2012
2014
Goal:
•Improved prognostic ability for:
•Recovery of strat. O_3 & impacts on surface UV
•Evolution of GHGs & impacts on climate
•Evolution of trop. O_3 & aerosols and impacts on climate & air quality

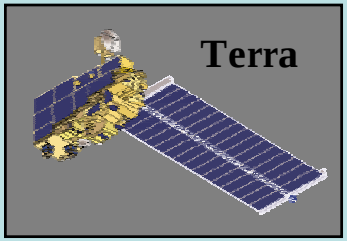
Focus Area Inputs

- Climate Data Records for Ozone and AerosolTrend Continuity
  - PK Bhartia and Chip Trepte
- Aura Mission Readiness and Validation Plan
  - Mark Schoeberl
- Aerosols-Clouds-Radiation/CCSP
  - Don Anderson
- Atmospheric Radiation
  - Paul Stackhouse

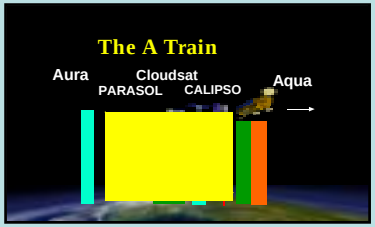
Aerosol Measurements from Space

1980-90's | **Late 1990's** | **2002-2010** | **2010-2014** | **2014 →**

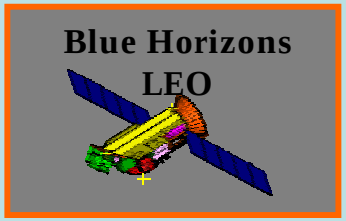
- POES AVHRR measurements of aerosols over the ocean
- Nimbus 7 TOMS measurements of absorbing and non-absorbing aerosols



- Terra MODIS/MISR instruments measure fine and coarse aerosol over land and water
- ADEOS POLDER provides first polarization measurements of aerosols from space



- Aqua MODIS continues measurements of Terra MODIS
- CALIPSO provides aerosol height information - flies behind Aqua MODIS
- Aura OMI continues the TOMS aerosol measurements
- PARASOL/ADEOS II makes polarization measurements using POLDER
- Glory makes precise polarization measurements - risk reduction for APS
- Cloudsat gives cloud droplet information
- NPP (2007) aerosol measurements using VIIRS and OMPS



- Blue Horizons LEO Combined multi-wavelength, polarization/ multi-angle/ height resolved imagery using lidar and glint measurements of black carbon
- Improved aircraft aerosol measurements
- Improved ground based instruments
- Improved models of aerosol climate forcing
- NPP continues aerosol measurements
- NPOESS (2012) aerosols with VIIRS, OMPS and APS

NPOESS

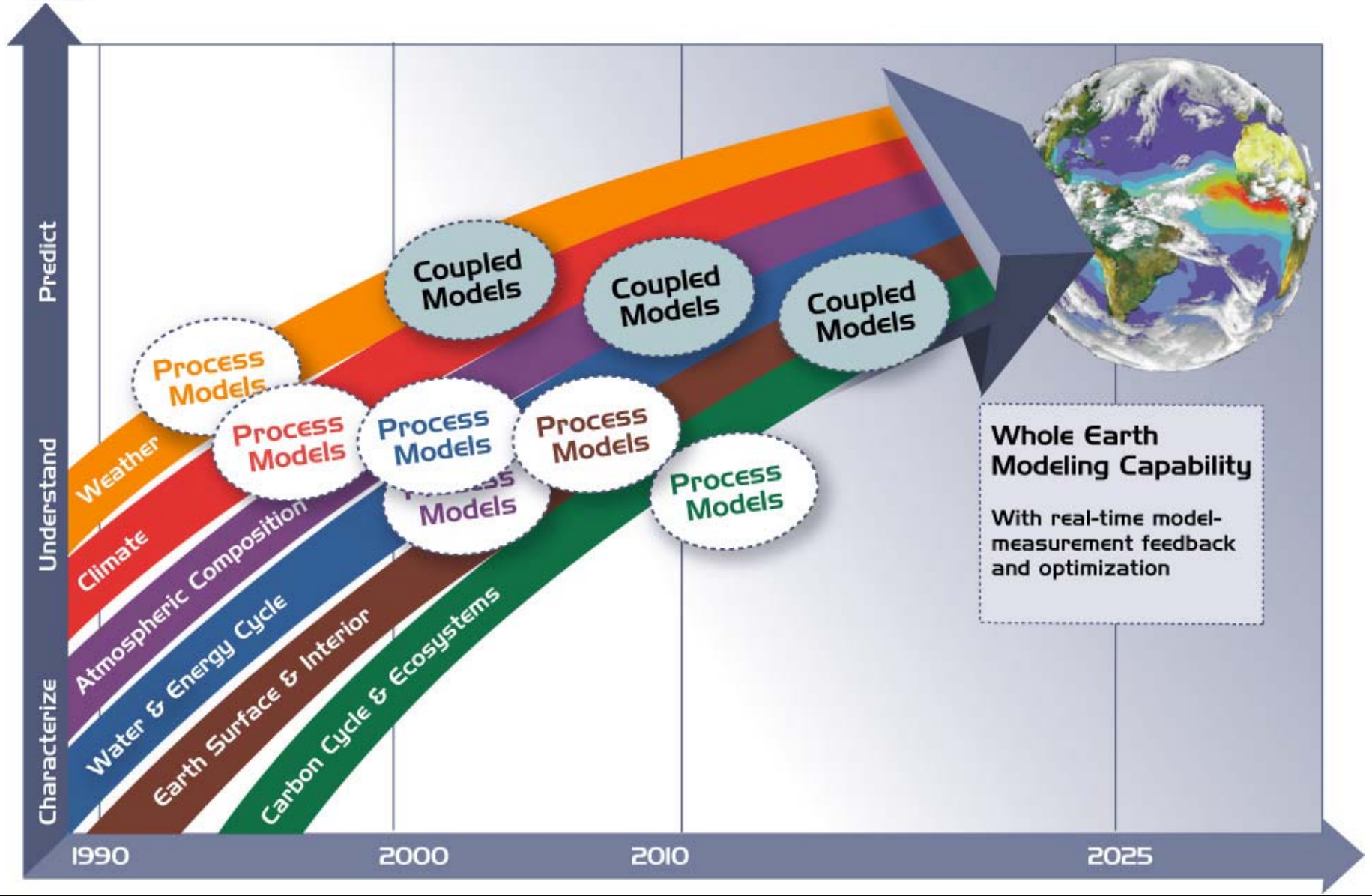
QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

- NPOESS continues aerosol measurements using VIIRS and OMPS and APS

Focus Area Outputs

- Global Modeling Initiative
  - Susan Strahan
- Building Towards Fully Interactive Models
  - Drew Shindell
- Constituent Assimilation
  - Steven Pawson
- Air Quality Modeling/Segue to Outcomes
  - Brad Pierce

Earth System Modeling



Focus Area Outcomes and Impacts

- Air Quality Applications
  - Lawrence Friedl
- WMO/UNEP, IPCC and Aviation Assessments
  - David Considine
- Education and Outreach
  - Ernie Hilsenrath

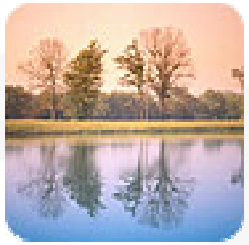
Applications of National Priority

Carbon Management

Public Health

Energy Forecasting

Aviation Safety



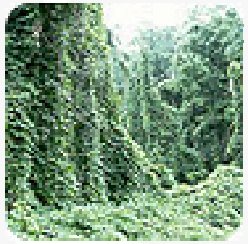
Water Management

Homeland Security

Coastal Management

Disaster Management

Agricultural Efficiency



Invasive Species

Community Growth

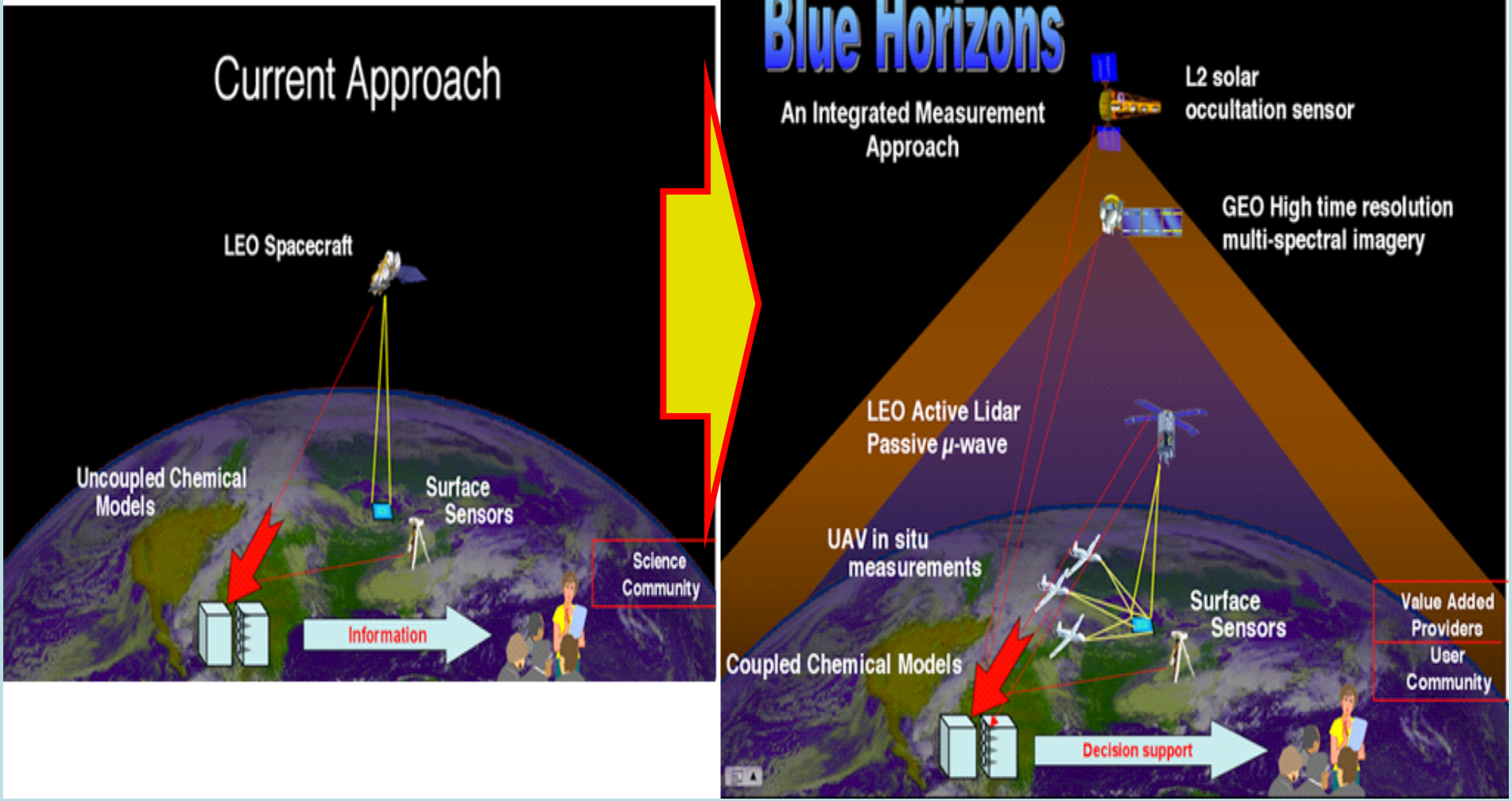
Air Quality

Focus Area Future Directions

- Current View of Remaining Uncertainties Motivating Future Strategy
  - Randy Friedl

- Future Global Observing System with Emphasis on Improved Temporal and Spatial Resolution Observations
  - GEO
    - Jim Gleason
  - L1/L2
    - Jay Herman
  - Role of LEO/Status of Active Sounding
    - R. Friedl
  - Role of UAVs
    - Paul Newman
  - Future Computational Needs
    - Ricky Rood

Blue Horizons:
Beyond Current Capabilities



A Mission Dedicated to the Health of the Earth's Atmosphere

Aura

- The Earth's Ozone Shield protects all life
- The Earth's Air Quality is fundamental to public health and ecosystems
- The Earth's Climate is affected by changes in atmospheric composition

Aura is designed to answer questions about changes in our life-sustaining atmosphere

Aura Mission Readiness and Validation Plan

EOS Aura is ready to open a new era in atmospheric constituent measurements

Motivation - Aura Science Goals:

- Is the ozone layer recovering as expected?
- What are the sources and processes that control tropospheric pollutants?
- What are the roles of upper tropospheric water vapor, aerosols and ozone in climate change?

Measurements:

- Global stratospheric constituent fields at high vertical and horizontal resolution including a new measurement of OH, BrO and HO_2
- New measurements of tropospheric constituent profiles and constituent columns at high horizontal resolution

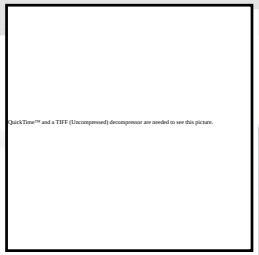
Status:

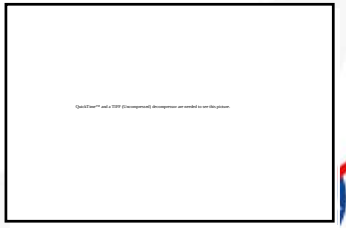
- January '04 launch (under review), SIPS are being tested
- Despite technological complexity, measurement complementarity/overlap means high likelihood for achieving science objectives
- Instrument validation plan in place - joint flights with CAMEX, INTEX, TC4
  - We expect to use UAV's in an experimental validation mode
  - A dedicated high altitude aircraft is required for validation

Outstanding Issues:

- Minor instrument changes have affected some L1 requirements and may both positively and negatively impact some science
- Uncertainties in sub-orbital program generate uncertainties in the Aura validation program
  - Tropospheric validation needs the use of a heavy lift, long range platform
  - Stratospheric validation needs a long range (~2000 km) high altitude (20 km) platform until '07
  - Ground based component (FAVOR) and data center (AVDC), discussions are ongoing.
  - Need help in identifying/clarifying resources for validation activities

Aura Validation Program





- Field Campaigns
  - Participate in two major tropical UT/LS campaigns
  - Host one tropical UT/LS campaign
  - Two tropospheric campaigns
  - Polar mini-campaign
- Frequent aircraft mini-missions
  - Targets different environments and seasons to exercise the algorithms (AVE)
  - UAV component (Partnership with the sub-orbital program)
- Ground based mobile trailer system for in situ and profile measurements (FAVOR)
- Special balloon flights for validation above 20km (e.g. Mark IV)
- Additional H_2O and O_3 sondes
- Aura Correlative Data Center for inter-satellite data comparison, hosting correlative data and mission planning (AVDC).
- New instrument development (NRA completed)

Inter-satellite/Suborbital/Network Validation Center: AVDC

- A significant amount of validation data will come from other satellites (especially for the stratosphere) and existing balloon networks (with augmentation)
- Collecting and archiving this data for validation effort does not require development of *new* measurement capabilities
- This effort does require the development of a data center to
  1. Create a measurement data base for aircraft & GB data
  2. Consolidate satellite and balloon data sources
  3. This effort does not duplicate the NASA DAAC's or other archives
- Requirements
  - Access and archiving relevant level 2 data sets from other satellite sources
  - Access and archival of ozonesonde and water vapor sonde data
  - Development of data base tools, HDF tools, and web based data access
  - Hosting mission planning, data conversion, and overpass location software